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USE OF POLYMERIC TRANSMISSION CABLES IN ONTARIO HYDRO - TASK FORCE REPORT

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This task force was set up to examine the future use of polymeric transmission cables in Ontario Hydro. Based on a comparison of polymeric and LPOF transmission cables, and a review of the availability and service record of polymeric transmission cables around the world, this report recommends the use of metal sheathed polymeric transmission cable as an acceptable alternative to LPOF cable in forthcoming 230 kV installations.

1.0 Introduction

Solid transmission cables with polymeric insulation have been successfully used since about 1969 at 230 kV and higher voltages up to 400 kV in Europe and Japan. However, North American utilities have been reluctant to accept these cables at 230 kV. This task force was set up to review the availability and use of solid transmission cables around the world, assess their reliability in service, and make recommendation(s) regarding their future use in Ontario Hydro.

This report makes a recommendation, which is justified on the basis of a comprehensive review of the state-of-the-art. The advantages and disadvantages of solid transmission cables and oil-paper cables are briefly described. The availability of solid transmission cables and the differences in their design from distribution class cables are identified. Experience with the use of polymeric transmission cables around the world is reviewed. Transmission cable installations planned for the next few years in Ontario Hydro are identified. Possible problem areas and solutions are described. Publications reviewed for preparation of this report are listed at the end.

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2.0 Recommendation

Based on comparable capital costs for polymeric and LPOF transmission cables (capital costs are very likely to go down in the future for polymeric cables), significantly lower maintenance costs (hence much lower lifetime costs) for polymeric cables, successful experience with the use of polymeric transmission cables up to 138 kV in Ontario Hydro (Thunder Bay) and about ten other North American utilities, and reliable operation of polymeric cables up to 400 kV in Europe and Japan, the use of metal sheathed polymeric transmission cable is recommended as an acceptable alternative to LPOF cable in forthcoming 230 kV installations.

3.0 Comparison of Polymeric and LPOF Cables

Oil-paper cables have been used reliably up to the highest transmission voltages. However, solid transmission cables with polymeric insulation offer many advantages over oil-paper cables:

a. reduced dielectric loss.
b. smaller charging currents and reactive power.
d. comparable capital cost and easier installation as no oil equipment is required. The price of polymeric cables is likely to drop with increased use by North American utilities.
e. elimination of oil requirement. This makes the polymeric cable more attractive because of
    i) better environmental acceptance,
    ii) less fire hazard,
    iii) no hydraulic problems on steep runs,
    iv) almost maintenance free operation; this is expected to be the most significant advantage over LPOF cables.
    v) potential for shorter time to repair as many steps, for example, oil draining, purging, filling, and site cleaning after repair are eliminated.

There is a clear worldwide trend of utilities moving away from the use of oil-paper cables towards the use of polymeric cables. The major impediments for application of solid transmission cables in North America have been the lack of experience with them and the perception that they may be unreliable based on North American experience with polymeric cables at the distribution levels. However, as detailed below, such fears may be unfounded as the polymeric transmission cables have a significantly improved design, and have proven to be reliable in service elsewhere in the world.

4.0 Difference From Distribution Cables

Polymeric distribution cables have been used quite reliably in Ontario Hydro since early seventies. Some North American utilities have experienced premature failures of polymeric distribution cables, caused mostly by water treeing. This experience at the distribution level has led to reluctance in using polymeric cables at 230 kV. However, manufacturers use much better quality of materials, designs and processing techniques for solid transmission cables. In particular, use of extra clean raw materials, controlled environment during processing, triple extrusion processes, and cross-linking in a dry atmosphere have practically eliminated potential causes of water treeing. In addition, some cables have impervious sheaths to keep water out. The trouble free use of polymeric transmission cables in various utilities around the world, as described below, confirms the effectiveness of these measures.

5.0 Availability of Polymeric Transmission Cables

5.1. Cable Manufacturers

At present there are no manufacturers of 230 kV polymeric transmission cables in North America, although, some manufactuers are presently reviewing the viability of developing such a capability. The following manufacturers in Europe and Japan have capability to supply 230 kV solid transmission cables:

ASEA (Sweden)
Cable de Lyon (France)
Felten & Guilleaume (Germany)
Hitachi (Japan)
Nokia (Finland)
Showa (Japan)
STK (Norway)
Brugg Cable (Switzerland)
Dainichi-Nippon (Japan)
Fujikura (Japan)
NKF (Holland)
Pirelli (UK, France and Italy)
Silec (France)
Sumitomo (Japan)

5.2 Specifications

There are no IEC or IEEE standards for 230 kV polymeric cables. Ontario Hydro can develop specifications based on standards used by European and Japanese utilities and manufacturers and guidelines issued by AEIC for 138 kV polymeric cables.

5.3 Terminations and Splices

Terminations and splices for polymeric cables have been developed and tested by different manufacturers. Factory made terminations and moulded splices are commonly used. The original installations in Ontario Hydro will be short in length and hence free of splices. However, for repair purposes, maintenance personnel must be trained in proper procedures for splicing and terminating the cables.

6.0 Use of Polymeric Transmission Cables

6.1 Users in North America

In North America use of polymeric transmission cables has been limited to 115/138 kV in about fifteen utilities listed in Table A. The first such installation was made in 1965. Ontario Hydro has had one 115 kV XLPE cable in service in Thunder Bay since 1976. The highest voltage rating in the U.S.A. is 161 kV for a cable installed by Iowa Power and Light Company in Des Moines in 1986.

6.2 Other Users

There are too many 100 kV to 200 kV polymeric transmission cable installations around the world to list them all. The length of installed cables is many tens of thousand kilometers. Even the list of countries with such cable installations is quite extensive: almost every country in Europe, Japan, Australia, Singapore, Malayasia, China, Korea, Bangladesh, India, Pakistan, Iran, Iraq, Kuwait, Abu Dhabi, Syria, Oman, Saudi Arabia, Jordan, Libya, South Africa, Brazil, Colombia, and many more.

The countries using polymeric cable installations above 200 kV are listed in Table B. In Japan there are many XLPE cable installations with and without splices at 187 kV. All 275 kV XLPE cable installations

in Japan are without splices and are given in Table C. EDF in France is the largest user of 220 kV polymeric cables with and without splices. Their first 220 kV polymeric cables were installed in 1969 and oil-paper cable is no longer used in new installations. EDF also has had some 420 kV polymeric cables in operation since 1985.

6.3 Reliability in Service

In general the experience of all users of polymeric transmission cables has been remarkably good. No dielectric failures have been reported. There have been some problems with splices and terminations, invariably within a short time after installation. This may be indicative of lack of experience or of quality control. For example, EDF had only 16 failures out of 2500 splices and terminations since 1969, all within the first few months of installation. This good service experience with polymeric transmission cables is quite similar to that of Ontario Hydro and other North American utilities with 115/138 kV polymeric cables.

7.0 Potential Applications in Ontario Hydro

Sites in Ontario Hydro, where polymeric cable can be installed in near future, are listed below:

Location	kV	length (km)	year
1. Vaughan TS 1	230	<1.0	1988
2. Rexdale TS	230	<1.0	1988

One reel may be purchased for both installations (including some spare length) to minimize costs.

8.0 Conclusions

Modern polymeric transmission cables have proven reliable in service and can be considered as an acceptable alternative to LPOF cable for the forthcoming installations. Proper procedures for splicing and terminating the cables must be made available and carefully adhered to. Such selective and gradual application of this technology in Ontario Hydro will help gain valuable in-house experience with this new type of cable. The capital cost of first few polymeric transmission cable installations may be the same as LPOF cable or even slightly more due to the lack of North American manufacturing capability. However, the installed cost of polymeric cables will eventually go down as manufacturing capability and utility use increase. More importantly, the use of polymeric cables has good potential for significant savings in maintenance costs and full life-cycle costs should be considered as the basis for cable selection.

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Table A

Use of Polymeric Transmission Cables in North America

User	*kV*	*year*	*sheath*	*Circuits no.*	*km*	*remarks*
Alabama Power	115	1971		1	0.3	
Baltimore G&E	115	1965		6	3.2	*
Cincinnati G&E	115		Pb	1	14.4	
Detroit Edison	138	1974		2	8.2	**
Duschene L	138	1971		2	0.5	
Florida P&L	138	65-75		1	0.5	
Indianapolis P&L	138	1977		1	0.2	
Iowa P&L	161	1986	Al	1	1.0	
Lincoln El	115	1975		1	8.8	
Ontario Hydro	115	1976		1	0.4	*
Philadelphia El	138	1972		2	0.3	
PSC of Colorado	115	1972			0.3	
Saskatchewan P	138	1987	Pb	1	1.7	
Tempa El	138	1975		1	1.0	
Wisconsin El	138	1969		1	0.2	

* Termination problems resolved
** Splice problems resolved.

Table B

Countries with Polymeric Cable Installations Above 200 Kv

Country	*kV*	*year*	*sheath*	*No. of Circuits*	*Length cct. km*	*remarks**
France (EDF)	225	1969	Pb,Al	many	240.0	LDPE, HDPE
	420	1985	Pb		3.0	LDPE
Norway	300	1980	--	2	3.8	
Sweden	245	1985	no	1	0.83	
Switzerland	220	1984	--	--	--	EPR
Japan	275	1980	Al	30	10.0	

* XLPE unless otherwise stated.

Table C

275 kV XLPE Cables Installed in Japan

P/S, S/S	Circuit length (cct.km)	Conductor size (mm^2)	Termination			Year of Commissioning	Utility	Maker	
			EB-A	EB-O	EB-G				
Okuyahagi P/S	2.03	600		15	15	1980	Chubu	H	First 275kV XLPE cable in the World
Koda S/S	0.11 0.14	600 600		3 3	3 3	1982 1985	Chubu	H	
Shinkeiyo S/S	0.27	800	3		3	1982	Tokyo	A	
Tamahara P/S	1.23 1.37 1.23	800 600 800	6 6	 6	6 6 6	1982 1982 1986	Tokyo	B	Altitude defference 220m
Hanamigawa S/S	0.12	800		3	3	1983	Tokyo	D	
Ageo S/S	0.04	800		3	3	1983	Tokyo	H	
Tohtomi S/S	0.13	600		3	3	1983	Chubu	A	
Joban S/S	0.22	1200		3	3	1984	Tokyo	H	
Nishiowari S/S	0.16	1000		6	6	1984	Chubu	B	
Ikegami S/S	0.16	800		6	6	1985	Tokyo	C	
Nishiyokohama S/S	0.15	800		3	3	1986	Tokyo	B	
Bokuto S/S	0.06	800		3	3	1986	Tokyo	E	
Nihombashi S/S	0.22	800		6	6	1986	Tokyo	A	
Shinharuna S/S	0.07	2000		3	3	1986	Tokyo	H	Largest size
Kitakatsushika S/S	0.12	600		3	3	1986	Tokyo	H	
Niiza S/S	0.15	1200		3	3	1986	Tokyo	D	
Nishiyokohama S/S	0.12	800		3	3	1986	Tokyo	A	
Suidobashi S/S	0.21	800		3	3	1986	Tokyo	H	
Shinkoga S/S	0.425	2000		3	3	1986	Tokyo	A	
Kitakatsushika S/S	0.08	600		3	3	1986	Tokyo	H	
Nihonbashi S/S	0.045 0.02	800 600			6 6	1986	Tokyo	A	
Soda S/S	0.18 0.15	1000 600		 3	6 3	1986	Tokyo	A	
Keihin S/S	0.18	600		3	3	1986	Tokyo	A	
Kitatokyo S/S	0.17	1000		3	3	1986	Tokyo	H	
Hamaoka-Shinsakura	0.48	600			6	1987	Chubu	H	

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